Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 18-19, 2017

Varification of Magnetostrictive Guided Wave Technique with an Elimination of Unwanted Geometry Signals for Detection and Monitoring of Defects in a Pipe Weld.

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1. Introduction

Long-range guided wave method has been applied to structures with simple geometry, because there are many unwanted signals due to the geometry are included in the acquired data, such as signals from welds, pipe supports, branch connections, reducers, etc. Unfortunately the defect is mostly founded in the weld regions and the defect signals overlapped to the geometry signals[1]. The method can be applied to the structural health monitoring to solve this problem[2]. An advantage of a magnetostrictive strip transducer for a long-range guided wave inspection is that the wave patterns are clear and simple when compared to a conventional piezoelectric ultrasonic transducer. The method can be useful to monitor the variation of the signals accurately and can related to the generation and growth of the defects[3-5].

A computer program for an accurate comparison and subtraction of guided wave signals were developed. The program contains an algorithm for calibration with the flight time and phases of ultrasonic signals in time domain. Once the reference signals were acquired at the beginning of monitoring, the signals can be compared to the reference and the signals due to the geometry can be removed accurately. An evolution of defect in a pipe can be monitored[6].

In this study a proof test were conducted to verify the ability of elimination of guided wave signals due to the geometry. Mechanical notches or corrosive defects were fabricated in the pipe weld regions and the acquired guided wave signals were analyzed.

2. Experimental Methods and Results

The dimensions pipe used for the experiment are a length of 3 m, diameter of 9 mm, schedule No. of 80. The material for the pipe was SA 106Gr. B. In order to investigate the effect of weld, two pieces of pipe was welded. Fig. 1 shows the experimental setup for the study. A magnetostricive strip(Fe-Co-V alloy) was glued to the outer surface of the pipe and circumferentially magnetized by a rotating the magnet. The ultrasonic guided waves were generated by a couple of the coils wounded on the strip. The torsion vibration mode, T(0,1) mode, was generated and received by the magnetolstrictive sensors. The T(0,1) vibration mode, has many advantages because it has no dispersion, no radial displacement, and a low attenuation coefficient.

Fig. 2 shows the reference signal from the weld of pipe. The weld signal was detected at the distance of 1.7m from the end of pipe.

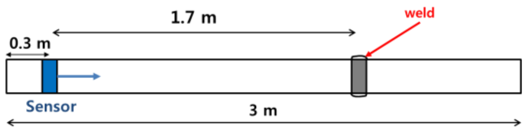

Fig. 1. Configuration the magnetostrictive sensor and the weld in the test pipe.

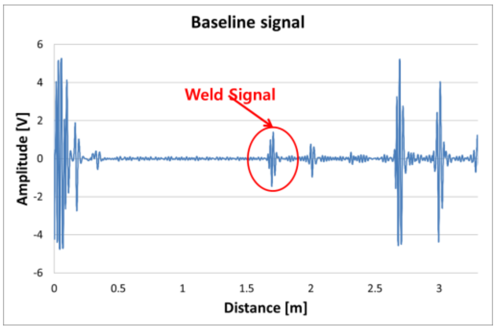

Fig. 2. Typical example of the reference signal of weld with no defect in a pipe.

A notch was fabricated in the weld and the acquired signal was compared to the reference signal. The acquired signal was matched in the time domain and reference signal was subtracted. In order to match the signals, an accurate calibration in phase and amplitude was performed to eliminate the environmental variation and the signals due to the geometry.

The signals were compared by generating a notch in the weld from 5 to 30 % depth of pipe thickness. As shown in the Fig. 3, the signal patterns were well matched in phase and amplitude. Fig. 4 shows the defect signals after calibration in phase and amplitude and subtracting the reference signal. An increase of amplitude was found as increase of depth of notch. The defect signals can be seen clearly, even the depth of notch is 5% of the pipe wall thickness, equivalent to the CSA(cross sectional area) of 0.48%. The distinction of the signal became clear in case of more than 1 % loss of the CSA.

Fig. 4 shows an example of guided wave signals acquired from a small notch (notch depth of 5% of pipe wall thickness) in the weld. Because of the amplitude of the weld signal is quite high compared to the small notch signals, it is not possible to acknowledge the presence of defect in the weld. After the discrimination of the baseline signal (weld signal) a very small defect can be detected.

Fig. 5 shows a similar result from a small corrosive defect (0.25 mm depth or 1.66% of CSA) in the weld region. We can see a small corrosion in the weld region, which was masked by a high geometry signal.

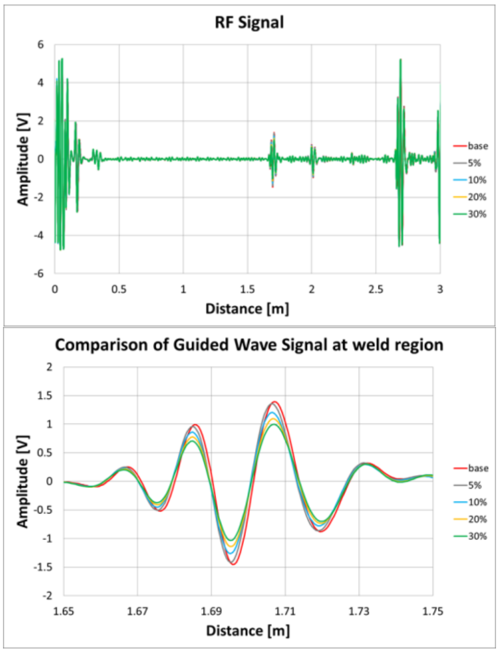

Fig. 3. Comparison of ultrasonic signals of various notches from 5 ~ 30 % of pipe wall thickness: RF signals overlapped (top) and magnified signals at the weld region with various depths of notches (bottom).

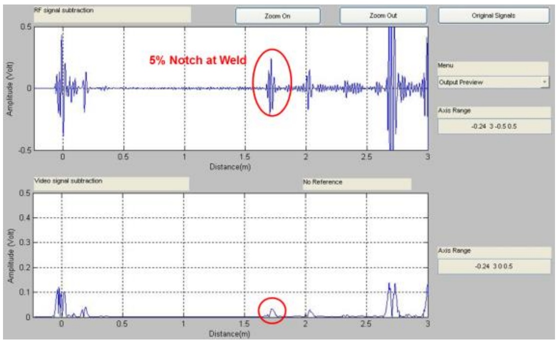

Fig. 4. A notch signals after discrimination of baseline weld signals. The depth of notch is 5 % of pipe wall thickness, which are equivalent from 0.48% loss of CSA.

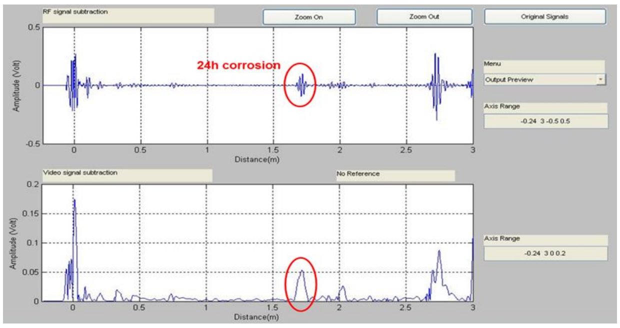

Fig. 5. A corrosion defect signals after discrimination of baseline weld signals. The depth of corrosive defect is 0.25 mm, which are equivalent from 1.66% loss of CSA.

3. Conclusions

In order to improve the detectability and solve the problems of the guided wave method, a computer algorithm and the programs were developed to eliminate the signals from the geometry, such as weld, pipe support, branch connection, etc. Proof test were conducted to verify the ability of elimination of guided wave signals due to the geometry. Mechanical notches or corrosive defects were fabricated in the pipe weld regions and the acquired guided wave signals were analyzed. The detection limit can be lower than 0.5% of CSA for the case of notches in the pipe weld and 2% of CSA for the case of corrosive defects.

The magnetostrictive guided wave technique with an elimination of the geometry can be used to detect or monitor the defect growth at the weld regions after a permanent installation of a simple magnetostrictive strip sensors. The guided wave technique developed in this study can be a useful tool for the inspection of pipe with limited accessibility, such as buried pipe or insulated pipe.

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